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Research Article

Measuring artificial intelligence literacy: The perspective of Indonesian higher education students

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As artificial intelligence [AI] increasingly permeates various sectors—including education, economics, healthcare, and government—a comprehensive understanding of this technology becomes essential. This analysis aims to identify four dimensions of AI literacy—awareness, usage, evaluation, and ethics—among Indonesian higher education students and examine the factors influencing AI literacy, including gender, age, and ownership of technological devices, through a descriptive-quantitative approach. A survey methodology was employed, utilizing an Artificial Intelligence Literacy questionnaire. The findings indicate that the level of AI literacy among higher education students remains relatively low, with many individuals demonstrating a limited understanding of the subject. These results underscore the necessity for intensified efforts to enhance students' comprehension and skills related to AI technology, enabling them to compete effectively in an increasingly digital job market. Recommendations include developing educational programs to elevate awareness and utilization of AI technology.

Keywords: Artificial intelligence literacy; Descriptive-quantitative; Higher education students; Measurement

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1. Introduction

Artificial intelligence [AI] technology has created a new paradigm in the digital era, necessitating mastery of AI literacy across various sectors. The demand for AI proficiency today extends beyond technology professionals (Bajaj, 2022; Gaur & Gaur, 2023; Sengsri & Khunratchasana, 2024), becoming essential for individuals in diverse fields, including education (Ahmad et al., 2021; Hang, 2024; Yetişensoy & Rapoport, 2023), economics (Aldasoro et al., 2024; Cetindamar et al., 2024), health, and government (Abdul & Kingdom, 2019; Lee et al., 2024). The emergence of AI has transformed numerous aspects of life, leading to significant changes in our interactions, work processes, and learning methods (Mahdi & Sahari, 2024; Sevnarayan, 2024). AI has revolutionized teaching and learning in the education sector, driving a profound transformation in instructional methodologies. In the era of Industrial Revolution 4.0 and Society 5.0, students must acquire practical knowledge on the effective application of technology, particularly AI, to adapt to the evolving demands of their respective disciplines (Anwar et al., 2024). Beyond merely integrating

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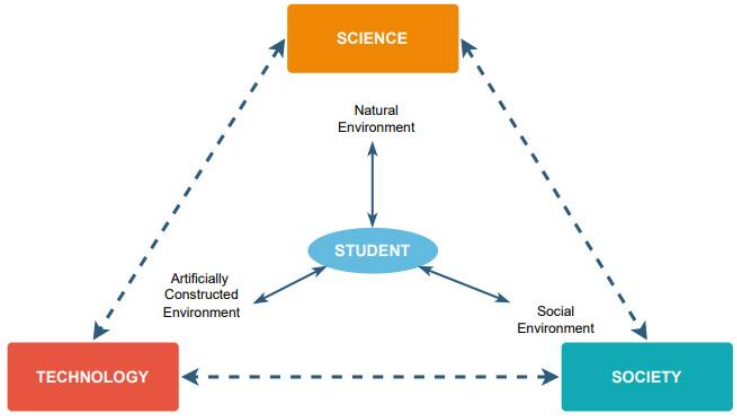
technology into education, it is essential to consider its social and ethical implications. The incorporation of AI and digital technologies in education necessitates a comprehensive approach that addresses both technical aspects and the interplay between science, technology, and society. Consequently, the Science, Technology, and Society [STS] framework has emerged as a pivotal approach (Allen & Kendeou, 2024; Bahroun et al., 2023), emphasizing the interconnectedness of scientific knowledge, technological innovation, and their societal impact. This framework fosters a holistic understanding among students, enabling them to grasp not only the mechanisms of technology but also its broader implications for society. The conceptual structure of the STS framework, which illustrates its core components and their interrelationships, is presented in Figure 1, offering a visual representation of its significance in integrating AI literacy within educational contexts.

Figure 1
The conceptual structure of the Science, Technology, and Society framework



AI literacy among higher education students, as the next generation, must be prioritized in every country. This emphasis is warranted because today's students will encounter numerous challenges in an increasingly technology-driven workforce (Hwang et al., 2023), including the necessity to master new skills and adapt to rapid changes. A report from the Organisation for Economic Co-operation and Development [OECD] in 2021 highlighted that the demand for AI skills in employment is closely linked to AI literacy, defined as an individual's understanding and capability to use, comprehend, and engage with AI technologies (Squicciarini & Nachtigall, 2021). In this context, Grace et al. (2018) predicted that AI would surpass human performance in various jobs within a decade, beginning in 2018. This prediction is already manifesting, as evidenced by the increasing implementation of AI assistance across diverse activities. For instance, AI is increasingly utilized for automatic language translation with remarkable accuracy, generating essays that demonstrate contextual understanding and a near-human writing style, as well as many other applications, including data analysis and facial recognition. This reality indicates that students with a profound sense of AI will be better positioned to compete in the dynamic job market, where skills in developing, implementing, and utilizing AI represent a considerable advantage. AI literacy empowers students to contribute to technological innovation, act as agents of change, and effectively address complex problems across various domains (Pinski & Benlian, 2024). Furthermore, AI literacy enables students to comprehend the ethical and social implications associated with AI utilization, fostering the development of responsible and sustainable technologies (Ng et al., 2021a; Zhang et al., 2023). The misuse of AI in education has the potential to compromise academic integrity and diminish higher education students' critical thinking and problem-solving skills by encouraging excessive reliance on AI-generated content (Squicciarini & Nachtigall, 2021). Consequently, mastering AI literacy is essential for students navigating an increasingly digital and technology-driven future.

AI literacy has been gaining increasing attention alongside the rapid advancement of artificial intelligence technology, particularly in education. Research indicates that China is the leading

country in AI implementation in education (Galung et al., 2024), which aligns with its rapid technological progress. As a developing country, Indonesia should consider this as a reference for its educational advancements. Indonesian students generally perceive AI positively, viewing it as a tool that facilitates skill development and enhances the engagement of learning processes (Patimah et al., 2024; Utami et al., 2023). However, integrating AI technologies also impacts academic norms and ethical standards (Haris et al., 2024), making understanding AI literacy essential within an educational context. Research on AI literacy among higher education students has been conducted at various universities in Indonesia (Hamsar et al., 2024; Juanda & Afandi, 2024; Zega & Batubara, 2024). However, these studies have not comprehensively described the AI literacy levels of higher education students at the national level, owing to its limitation in encompassing only a specific subset of regions in Indonesia. The level of AI Literacy among Indonesian higher education students is crucial to comprehend, as it serves as an indicator of their preparedness for the digital era, particularly in addressing the disparities in technological access across regions. Therefore, further research involving a broader and more diverse sample is essential to achieve a comprehensive understanding of AI literacy among higher education students in Indonesia. This investigation seeks to assess the AI literacy levels of higher education students across the nation and examine the factors that influence their proficiency in this area. To address the identified gaps, this research seeks to answer the following research questions:

RQ 1) What is the AI literacy level of Indonesian higher education students, considering variables such as gender, age, region, and device ownership?

RQ 2) What factors contribute to the levels of AI literacy among Indonesian higher education students?

2. Literature Review

2.1. Artificial Intelligence

Artificial Intelligence has evolved significantly since its inception in the 1950s, with extensive applications across various sectors. John McCarthy recognized as the founding figure of AI, defined it as the science and engineering of creating intelligent machines (Mccarthy, 1959). Turing (1950) posited that a machine is deemed intelligent if it can exhibit behaviour indistinguishable from a human's. Currently, the adoption of AI has escalated rapidly within the industrial landscape. According to a recent report, 80% of companies incorporate AI into their production activities, with 30% planning to augment their investments in AI over the next three years and 62% intending to recruit specialists adept in managing AI technologies (Bughin et al., 2018). In light of the swift integration of AI in the workforce, students must acquire AI-related competencies to remain competitive in the global market (Kumar, 2023; Sengsri & Khunratchasana, 2024). A comprehensive understanding of AI, coupled with the ability to apply it across diverse contexts, will equip students to contribute effectively in an increasingly digital and data-driven work environment (Chao et al., 2021). With sufficient AI proficiency, students will be better positioned to meet the demands of future industries, enhance their career prospects, and develop into an adaptable workforce capable of navigating global technological advancements.

Artificial Intelligence has emerged as a transformative force in education and research, presenting both significant opportunities and considerable challenges for academics. While many educators acknowledge AI's potential in enhancing information retrieval and the preparation of teaching materials, concerns regarding its misuse, particularly in plagiarism and research integrity, remain prevalent (Titko et al., 2023). The increasing necessity for AI literacy among educators highlights the importance of equipping them with advanced skills such as prompt engineering and critical thinking to adapt to these evolving demands (Walter, 2024). However, current higher education programs often inadequately prepare graduates for AI-integrated job markets, revealing gaps in professional certification, proficiency in specialized tools, and awareness of the ethical implications of AI (Benhayoun & Lang, 2021). Policymakers are encouraged to prioritize the integration of AI into sustainable education strategies, particularly in developing nations, to

enhance both the quality and accessibility of education (Tanveer et al., 2020). Effectively addressing these challenges calls for integrating AI skills into education, and preparing educators and graduates for an AI-driven future.

2.2. Artificial Intelligence Literacy

Our lives have experienced significant transformations due to the advent of artificial intelligence technology. As an increasing number of smart devices and applications are integrated with AI, understanding the concept of AI literacy becomes imperative, as it encapsulates individuals' competencies in utilizing AI technology. As defined by experts, AI literacy encompasses a set of knowledge and skills that empower non-experts to comprehend, critically evaluate, and effectively employ AI technology across various contexts. According to Laupichler et al. (2023) with Long and Margeko (2020), AI literacy involves a foundational understanding and the ability to assess AI technology and utilize and interact with AI applications in diverse environments, including home and workplace settings. Additionally, Lérias et al. (2024) expanded this concept by highlighting the importance of skills in applying and using AI in daily life. Wang et al. (2022) further defined AI literacy as the capacity to master the applications of AI technology, select and critically evaluate information generated by AI, and maintain an awareness of ethical and social responsibilities when engaging with this technology. The study by Ng et al. (2021b), classified AI literacy into four primary dimensions to establish a more systematic framework: (1) understanding fundamental AI concepts as a basis for training; (2) applying AI concepts in practical contexts to enhance AI education; (3) evaluating and critically engaging with AI technology in its respective contexts; and (4) the ability to comprehend and consider the evolving ethical implications arising from AI applications. In alignment with these proposed dimensions, Wang et al. (2022) identified four dimensions to measure AI literacy: awareness, usage, evaluation, and ethics. This study will employ these four dimensions to assess the AI literacy of higher education students in Indonesia. Furthermore, this study will also consider factors such as gender, age, region, and ownership of technological devices. Therefore, the hypotheses proposed for this study are as follows:

H1: AI literacy among higher education students does not significantly differ by gender.

H2: AI literacy among higher education students shows no significant variance across different age groups.

H3: AI literacy among higher education students is consistent regardless of geographical area of residence.

H4: AI literacy levels among higher education students are similar irrespective of technological device ownership.

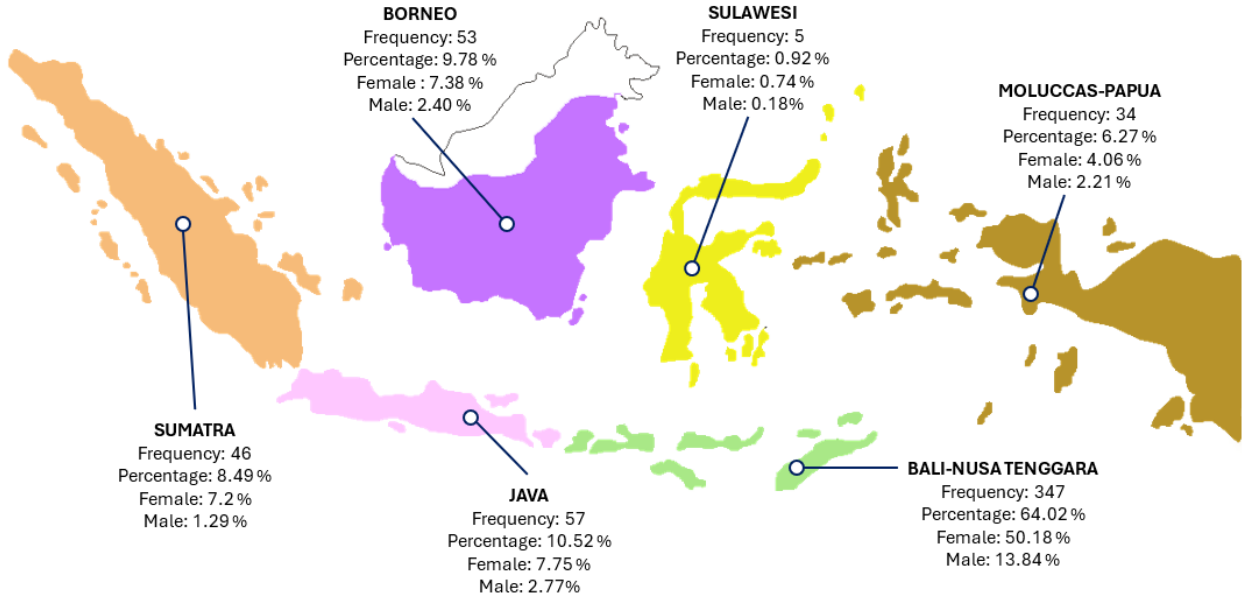
3. Method

This study employed a descriptive-quantitative approach to identify the AI literacy levels of self-directed Indonesian higher education students. Additionally, it explored variations in AI literacy based on gender, age, region, and device ownership.

3.1. Participants

The sample was selected using a purposive sampling technique, targeting higher education students across Indonesia. The grouping of six regions—Sumatra, Java, Borneo, Sulawesi, Bali-Nusa Tenggara, and Moluccas-Papua—was not intended to restrict the scope to specific areas but rather to provide a structured representation of Indonesia's geographical diversity. Smaller areas within these regions were also included to ensure comprehensive coverage, reflecting the nation's diverse socio-cultural and economic characteristics. The selection process employed purposive random sampling by distributing questionnaires to universities across various regions in Indonesia. The respondents who participated in this study included 542 final-year students in their fifth semester. The demographic characteristics of the sample are illustrated in Figure 2.

Figure 2
The demographics of the participants



Gender

Group	Frequency	Percentage
Female	419	77.31 %
Male	123	22.69 %

Age (years)

Group	Frequency	Percentage
15-20	418	77.21 %
21-25	119	21.96 %
> 25	5	0.92 %

Device Ownership

Group	Frequency	Percentage
No Devices	23	4.24 %
1 Device	359	66.24 %
2 Devices	130	23.99 %
≥ 3 Devices	30	5.54 %

3.2. Measure

The AI literacy survey conducted among Indonesian higher education students employed a questionnaire adapted from Wang et al. (2022), encompassing four key aspects: awareness, usage, evaluation, and ethics. Awareness pertains to recognizing and understanding AI technology when utilizing relevant applications. Usage focuses on proficiency in applying and utilizing AI technologies to accomplish tasks effectively. Evaluation emphasizes the capacity to analyze, select, and assess AI applications and their outcomes. Meanwhile, ethics encompasses understanding AI technologies' responsibilities and potential risks. Based on these four aspects, 12 items were developed to measure students' AI literacy. These items were subsequently organized into a questionnaire utilizing a 5-point Likert scale to gauge the level of agreement, ranging from 'very low' (1 point) to 'very high' (5 points), resulting in ordinal data. The AI literacy questionnaire (see Table 1), originally developed and validated by Wang et al. (2022), demonstrated robust psychometric properties, with an average factor loading for construct validity exceeding 0.72 and a Cronbach's alpha reliability coefficient of 0.83. The instrument was further subjected to content validation in this study to ensure its suitability within the research context. The content validity, assessed using Aiken's V, yielded a value of 0.96, indicating a high level of validity.

3.3. Data Analysis

The survey results were subsequently converted into interval data utilizing the method of successive intervals (Nunnally & Bernstein, 1994). This conversion processed entails specific steps in which the ordinal scores derived from the questionnaire were transformed into interval scores for subsequent analysis. The resulting interval data was analyzed using mean score interpretation, with the interpretation criteria established based on the number of items and the scale employed. In alignment with the mean score interpretation calculation method proposed by Alkharusi (2022), a 5-point interval scale was generated based on the number of items and the corresponding mean scores, as presented in Table 2.

Table 1
Description of AI Literacy Questionnaire

Item	*Description*	*Aspects*
1	I can distinguish between smart devices and non-smart devices.	Awareness
2	I do not know how AI technology can help me.	Awareness
3	I can identify the AI technology employed in the applications and products I use.	Awareness
4	I can skilfully use AI applications or products to help me with my daily work.	Usage
5	It is usually hard for me to learn to use a new AI application or product.	Usage
6	I can use AI applications or products to improve my work efficiency.	Usage
7	I can evaluate the capabilities and limitations of an AI application or product after using it for a while.	Evaluation
8	I can choose a proper solution from various solutions provided by a smart agent.	Evaluation
9	I can choose the most appropriate AI application or product from a variety for a particular task.	Evaluation
10	I always comply with ethical principles when using AI applications or products.	Ethics
11	I am never alert to privacy and information security issues when using AI applications or products.	Ethics
12	I am always alert to the abuse of AI technology.	Ethics

Note. Adopted from Wang et al. (2022).

Table 2
The 5-point scale of class intervals for interpreting the scores using sum and average

Interval (sum)	*Interval (average)*	*Interpretation*
12.00 – 21.60	1.00 – 1.80	Very low
21.61 – 31.20	1.81 – 2.61	Low
31.21 – 40.80	2.62 – 3.42	Moderate
40.81 – 50.40	3.43 – 4.23	High
50.41 – 60.00	4.24 – 5.04	Very high

Note. The calculation follows Alharusi's (2022) methodology.

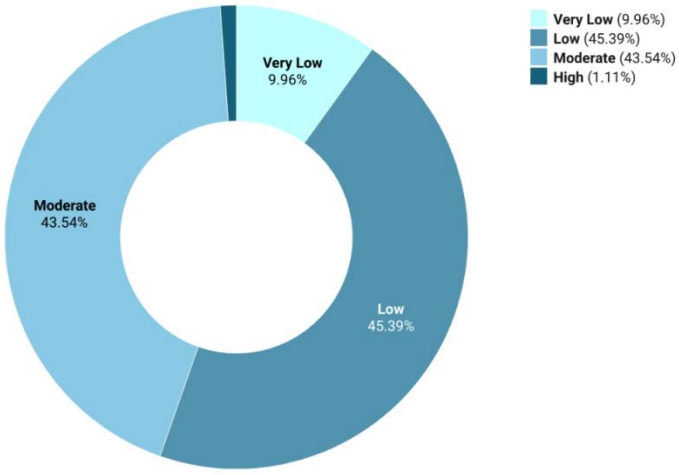
The obtained data were subsequently analyzed to ascertain differences between groups based on gender, age, and region, employing the Kruskal-Wallis analysis. The Kruskal-Wallis test was selected due to its robustness against outliers, making it a more appropriate choice compared to parametric methods, which are highly sensitive to extreme data values. If the Kruskal-Wallis test revealed significant differences between the groups, the Mann-Whitney U test was conducted further to explore the differences between the two specific groups. Based on these statistical results, the findings will be elaborated on in detail.

4. Result

The survey, which included 542 higher education students from various regions in Indonesia, revealed an average AI literacy score of 2.52 with a standard deviation of 0.48. According to the interpretation outlined in Table 1 for the mean interval (Alkharusi, 2022). This score is categorized as 'low'. This finding suggests that overall, AI literacy among higher education students in Indonesia is generally low. Specifically, the distribution of students' AI literacy levels is illustrated in Figure 3, which indicates that most students fall within the 'Low' to 'Moderate' level. Nevertheless, a subset of students has attained an AI literacy level classified as 'High,' highlighting the variation in understanding and application of AI among the student population.

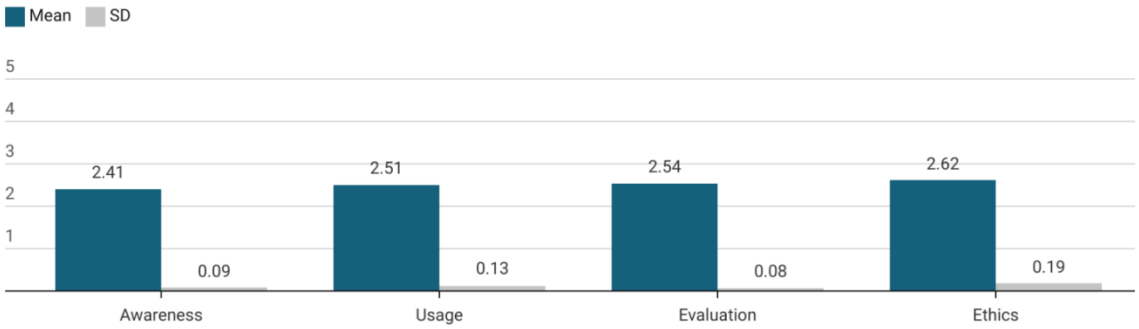
Based on the comprehensive analysis conducted through the AI Literacy questionnaire, detailed information regarding the average score achievements for each aspect has been identified. The results of the study indicate that the average interval scores for the aspects of awareness, usage, and evaluation fall within the 'Low' level. Conversely, the ethics aspect demonstrates an average interval score categorized as 'Moderate.' This distinction is clearly illustrated in Figure 4. These

Figure 3
Distribution of AI Literacy Levels of Higher Education Students in Indonesia



findings suggest that while Indonesian higher education students exhibit a relatively low understanding of AI's awareness, usage, and evaluation aspects, they possess a comparatively better understanding of the ethical considerations associated with AI.

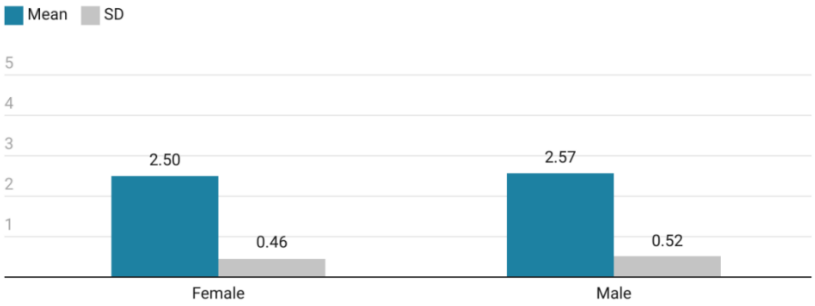
Figure 4
AI Literacy Levels by Aspects



4.1. AI Literacy by Gender

A gender-based study assessed the AI literacy of male and female students. The analysis results reveal that both genders exhibit the same literacy level, classified as 'low.' The results of the Kruskal-Wallis U test yielded a statistic of 2.795, with a degree of freedom [df] of 1 and a p-value of 0.095. A p-value greater than 0.05 indicates that the difference in AI literacy between genders is not statistically significant (Kraska-Miller, 2014). Therefore, the level of AI literacy among Indonesian higher education students is not significantly influenced by gender. Figure 5 illustrates the distribution of AI literacy levels by gender, demonstrating uniformity in literacy levels between male and female students.

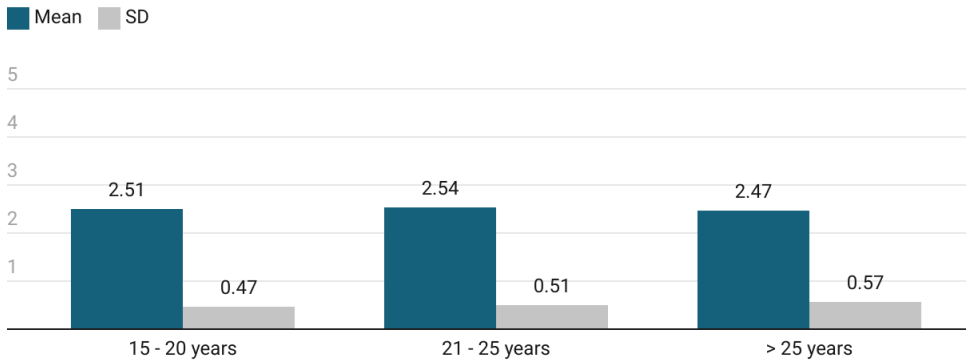
Figure 5
AI Literacy Levels by Gender



4.2. AI Literacy by Age

Based on the analysis of AI literacy conducted among higher education students in Indonesia, respondents were categorized into three age groups: 15-20 years (77.21%), 21-25 years (21.96%), and above 25 years (0.92%). The distribution of students' AI literacy levels by age is presented in Figure 6. A Kruskal-Wallis H test was performed to examine potential significant differences among the age groups, resulting in a statistic of 1.033, with a degree of freedom of 2 and a p-value of .597. This means that the differences in AI literacy among the age groups are not statistically significant. This finding indicates that AI literacy among Indonesian higher education students is relatively uniform, with no significant variations based on age, suggesting that the understanding and application of AI literacy are not influenced by age.

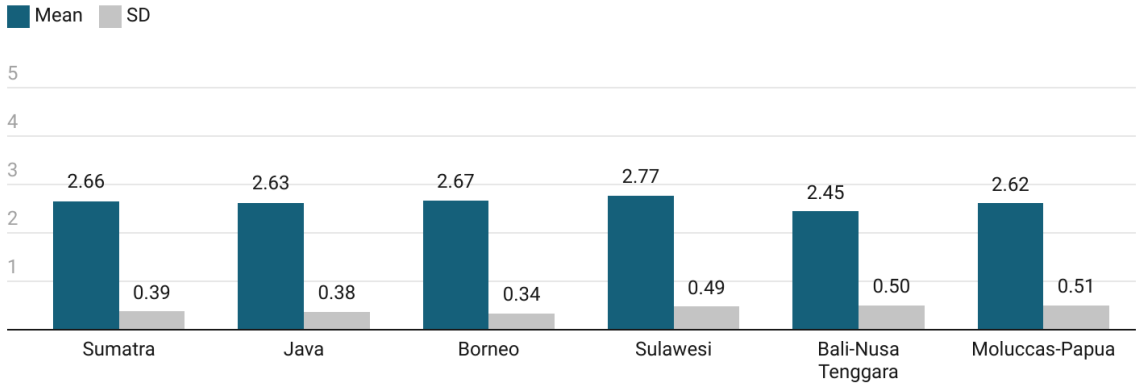
Figure 6
AI Literacy Levels by Age



4.3. AI Literacy by Region

Considering Indonesia's status as an archipelago characterized by diverse regions, students' AI literacy was analyzed based on their institutional affiliation. The findings indicate that AI literacy levels in most regions are categorized as 'moderate.' In contrast, the Bali-Nusa Tenggara region is identified as the only area exhibiting a 'low' level of AI literacy. These disparities are influenced by differences in socioeconomic conditions, the availability of technological infrastructure, and varying levels of access to educational resources across Indonesian regions. The distribution of students' AI literacy by region is illustrated in Figure 7. The results of the Kruskal-Wallis H test revealed statistics of 19.066, with a degree of freedom of 5 and a p-value of .002. This finding indicates a statistically significant difference in AI literacy among the various regions of Indonesia.

Figure 7
AI Literacy Levels by Region



Further analysis was conducted to identify differences between the two regions using the Mann-Whitney U test (Kraska-Miller, 2014). The results of the Mann-Whitney U test indicate a significant difference between the Sumatra, Java, and Borneo regions compared to the Bali-Nusa

Tenggara regions ($p < .05$).Table 3 provides a more detailed distribution of the Mann-Whitney U test results. This finding suggests that the level of artificial intelligence literacy in the Sumatra, Java, and Borneo regions is statistically different from the level of AI literacy in Bali-Nusa Tenggara.

Table 3
Mann-Whitney U Test Results by Region

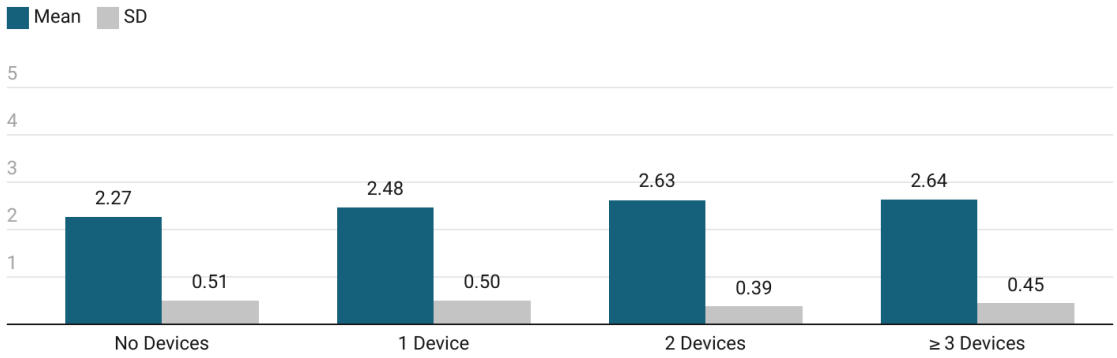
Group	*Mann-Whitney U*	*Z*	*p-value*	*Conclusion*
Sumatra – Java	1258.500	−0.348	.728	Insignificant
Sumatra – Borneo	1212.500	−0.46	.964	Insignificant
Sumatra – Sulawesi	90.500	−0.776	.448	Insignificant
Sumatra – Bali-Nusa Tenggara	**6186.000**	**−2.483**	**.013**	**Significant**
Sumatra – Moluccas-Papua	775.000	−0.068	.946	Insignificant
Java – Borneo	1453.500	−0.341	.733	Insignificant
Java – Sulawesi	108.500	−0.879	.379	Insignificant
Java – Bali-Nusa Tenggara	**7907.000**	**−2.430**	**.015**	**Significant**
Java – Moluccas-Papua	943.500	−0.209	.834	Insignificant
Borneo – Sulawesi	98.500	−0.942	.346	Insignificant
Borneo – Bali-Nusa Tenggara	**6926.000**	**−2.912**	**.004**	**Significant**
Borneo – Moluccas-Papua	892.000	−0.078	.938	Insignificant
Sulawesi – Bali-Nusa Tenggara	497.000	−1.643	.100	Insignificant
Sulawesi – Moluccas-Papua	66.500	−0.777	.437	Insignificant
Bali-Nusa Tenggara – Moluccas-Papua	4886.500	−1.655	.098	Insignificant

Note. Analysis using JASP (Jeffrey's Amazing Statistics Program) software.

4.4. AI Literacy by Device Ownership

Students' AI literacy was also analyzed, including their ownership of technological devices such as smartphones, laptops, tablets, and other equipment. The results indicated that students who owned two or more devices (≥ 3 devices) exhibited a 'moderate' level of AI literacy. In contrast, students who owned no or only one device were categorized as having a 'low' level of AI literacy. The distribution of AI literacy levels based on device ownership is illustrated explicitly in Figure 8. The results of the Kruskal-Wallis H test for groups based on device ownership revealed a value of 11.765, with three degrees of freedom and a p-value of .008. This finding suggests a significant difference in AI literacy levels among university students based on their device ownership.

Figure 8
AI Literacy Levels by Device Ownership



Based on the findings of the previous analysis, which indicated a significant difference between groups based on device ownership, a further analysis using the Mann-Whitney U test was conducted to identify the differences between the two device ownership groups (Table 4). The results of the Mann-Whitney U test revealed a significant difference between the group of students who did not own a device and those who owned one device (Kraska-Miller, 2014). However, comparisons between other student groups did not indicate significant differences, suggesting

similarities in AI literacy levels among those groups. This finding underscores the importance of device ownership in enhancing AI literacy, as students who own at least one device tend to have a better understanding than those who do not own any devices.

Table 4
Mann-Whitney U Test Results by Device Ownership

Group	*Mann-Whitney U*	*Z*	*p-value*	*Conclusion*
No Devices – 1 Device	**19233.000**	**−2.974**	**.003**	**Significant**
No Devices – 2 Devices	3702.000	−1.155	.248	Insignificant
No Devices – ≥ 3 Devices	380.000	−1.621	.105	Insignificant
1 Device – 2 Devices	1467.000	−0.463	.643	Insignificant
1 Device – ≥ 3 Devices	157.000	−1.347	.178	Insignificant
2 Devices – ≥ 3 Devices	32.500	−1.018	.308	Insignificant

Note. Analysis using JASP (Jeffrey's Amazing Statistics Program) software.

5. Discussion

The findings of this study reveal that AI literacy among Indonesian higher education students remains at a concerningly low level, particularly in the dimensions of awareness, usage, and evaluation. This outcome contrasts with the study conducted by Haris et al. (2024), which identified the ethical aspect as the primary area requiring improvement in students' AI literacy. The observed discrepancy is likely attributable to the limited scope of the study, which involved a small and homogenous sample, thereby failing to capture the broader variations within the student population (Haris et al., 2024). This gap underscores the insufficient foundational knowledge and practical engagement of students with AI technologies, despite the growing integration of AI into various academic and professional domains (Wang et al., 2022). The relatively moderate score in the ethics dimension suggests a preliminary understanding of the moral considerations surrounding AI usage. However, the lack of comprehensive AI literacy across all dimensions limits students' capacity to leverage AI technologies in problem-solving and decision-making effectively. AI technologies offer significant advantages for university students by enhancing their academic and collaborative experiences. AI-powered research tools, such as semantic search engines and reference management software, streamline the process of finding relevant academic literature and organizing citations efficiently. Moreover, AI-driven language models provide real-time writing assistance, helping students refine their academic writing and minimize plagiarism through effective paraphrasing. In collaborative settings, AI-based project management tools facilitate teamwork by automating task distribution and progress tracking. Collectively, these applications not only improve learning efficiency and academic performance but also equip students with essential problem-solving skills for their future careers.

The low awareness of AI among students highlights their limited understanding of its potential and applications in educational and everyday contexts, as emphasized by Wang et al. (2022). This lack of awareness translates into restricted usage, with students predominantly relying on common applications without exploring more complex or innovative functionalities. Moreover, students exhibit significant deficiencies in evaluating the reliability and relevance of AI-generated information, as noted by Laupichler et al. (2023), underscoring the need to strengthen their critical analysis skills. While ethical awareness appears relatively stronger, it still requires reinforcement to address concerns such as data privacy and security. This supports the perspective of Zhang et al. (2023), which stresses the integration of ethical considerations into AI literacy education to foster responsible and sustainable technological development.

These results emphasise the urgent need for educational interventions that address AI literacy's technical and ethical aspects (Ng et al., 2021b; Zhang et al., 2023). In addressing these deficiencies, a comprehensive strategy is required, encompassing curriculum enhancement, equitable access to technological resources, and the integration of experiential learning opportunities. Such measures are essential to developing students' foundational knowledge and practical skills in AI

technologies while simultaneously fostering an understanding of their ethical implications. By strengthening both the technical and ethical dimensions of AI literacy, higher education institutions can prepare students to navigate the complexities of the digital era, enhancing their capacity to contribute meaningfully to a technology-driven society.

The findings align with constructivist learning theory, which posits that meaningful learning requires active engagement and interaction with the subject matter (Zulfiani et al., 2020). The low scores in awareness, usage, and evaluation could be attributed to insufficient opportunities for experiential learning and critical engagement with AI technologies. Moreover, regional disparities highlight the role of access to resources and infrastructure in shaping students' learning outcomes (Kantar et al., 2020; Magableh & Abdullah, 2022), as suggested by Vygotsky's Social Development Theory and his concept of the Zone of Proximal Development. These results are consistent with Zhao et al. (2022), who identified resource availability as a key determinant of AI literacy. To address these gaps, the implementation of targeted, context-specific educational strategies, such as problem-based learning (Dinata & Suparwoto, 2018), project-based learning (Balemen & Özer Keskin, 2018; Kokotsaki et al., 2016), and the equitable distribution of technological resources, is critical for enhancing students' competency and readiness in navigating a technology-driven future. Implementing targeted educational strategies and addressing resource disparities are critical for fostering equitable AI literacy and preparing students to effectively engage in a technology-driven global landscape.

The findings of the study indicate insignificant differences in AI literacy based on gender or age, suggesting that these demographic factors do not substantially influence students' understanding and utilization of AI technologies. This outcome supports the acceptance of hypotheses 1 and 2, which propose the uniformity of AI literacy across gender and age groups. The absence of gender-based disparities implies that male and female students possess relatively similar levels of AI literacy. However, this result diverges from previous research, such as Aldasoro et al. (2024), which identified a notable gap in AI usage, with female students less likely to engage with AI technologies than their male counterparts. Furthermore, Ahn et al. (2022) reported higher competence in AI usage among males, whereas females exhibited stronger perceptions of connectedness to AI systems. These prior findings suggest the potential presence of gender bias, although such biases were not evident in this study. The lack of observed differences may be attributable to the predominance of female participants or the limited depth of gender-specific analysis. This underscores the need for further research to investigate potential gender-based variations in AI literacy using more comprehensive approaches, including quantitative and qualitative methodologies. A deeper examination could uncover nuanced disparities in aspects such as engagement patterns or the perceived importance of AI literacy. Such insights are essential for developing targeted strategies to address any existing gender-based inequities in AI education and to promote equitable access to and understanding of AI technologies among diverse student populations.

Furthermore, insignificant differences in AI literacy based on the age of higher education students, indicating that students across different age groups possess relatively similar levels of AI literacy. This uniformity suggests that equal access to AI technologies may contribute to consistent literacy levels across age demographics. However, this outcome diverges from prior studies, such as those conducted by Lee et al. (2024) and Syafiuddin et al. (2024), which identified significant age-based variations. Lee et al. (2024) reported that younger students, particularly freshman, exhibit lower levels of AI literacy compared to their senior counterparts, due to limited exposure to and experience with AI technologies. Similarly, Syafiuddin et al. (2024) attributed higher AI literacy levels among university students to their upbringing in the digital era and greater access to technological tools. The discrepancies between this study and previous research may be attributed to the specific characteristics of the respondents. In this study, participants were predominantly in the same academic semester, potentially limiting variability in age-related AI literacy. This homogeneity could explain the lack of observed differences across age groups. To address this

limitation, future research should encompass a more diverse sample, including both freshmen and senior students, to provide a broader and more nuanced understanding of the relationship between age and AI literacy. By incorporating participants at varying stages of their academic journey, subsequent studies can better capture the developmental and experiential factors that may influence AI literacy.

Subsequently, the findings of this study underscore the significant influence of geographical context on AI literacy, with notable disparities observed across different regions in Indonesia. As an archipelagic nation characterized by diverse socio-economic conditions, Indonesia faces unequal access to technological resources and educational opportunities. The economically developed Java region, which benefits from advanced infrastructure and abundant technological resources, demonstrates higher levels of AI literacy compared to less-developed regions such as Bali and Southeast Nusa Tenggara. These regions encounter significant challenges related to limited access to technology and inadequate comprehension of its applications, thereby constraining their ability to integrate AI effectively into education and daily life. This pattern aligns with Zhao et al. (2022), who highlighted the critical role of regional factors in shaping individual AI literacy levels. Their study emphasized that resource availability and institutional support significantly influence the capacity of individuals to engage with and utilize AI technologies. The disparities observed in this study reaffirm the necessity of targeted interventions to address these inequities. Strategic investments in infrastructure, coupled with region-specific educational programs, are essential to ensure equitable access to AI technologies across all regions of Indonesia. Such initiatives would not only bridge the digital divide but also empower individuals in less-developed areas to leverage AI for educational and professional advancement.

Additionally, the findings of this study underscore the significant role of device ownership in shaping AI literacy among higher education students. Students who own multiple technological devices, such as smartphones, laptops, or tablets, consistently demonstrate higher levels of AI literacy compared to their peers with fewer or no devices. This suggests that increased access to technological tools provides more opportunities for students to engage with AI applications, enhancing both their understanding and practical skills. The frequent interaction with various AI-enabled technologies allows these students to develop a broader range of competencies and a deeper familiarity with AI functionalities. Conversely, students with limited access to such devices face significant barriers in learning and applying AI technologies effectively. This digital divide hampers their ability to engage with AI-driven tools and restricts their exposure to innovative applications, limiting their skill development. These findings are consistent with the study by Hornberger et al. (2023), which demonstrated that students with greater experience using AI technologies exhibit higher levels of AI literacy. Ownership of multiple devices enables students to explore diverse AI functionalities and gain practical experience, thereby broadening their knowledge base and increasing their proficiency. The implications of these findings are critical for addressing inequities in AI literacy. Ensuring equitable access to technological devices is essential for fostering comprehensive engagement with AI technologies among students from diverse socio-economic backgrounds. Educational institutions and policymakers must prioritize initiatives that provide resources and support for students with limited access to technology, thereby promoting an inclusive approach to technological education.

This study underscores the importance of addressing regional disparities and technological device ownership in strategies to improve AI literacy among college students. A comprehensive and inclusive approach is crucial to ensure equitable opportunities for all students, regardless of their geographic location or access to technology, enabling them to develop and enhance their AI literacy effectively.

5. Conclusion

This study reveals that AI literacy among Indonesian higher education students remains low, with many students exhibiting low to moderate literacy levels. While certain individuals exhibit a

proficient understanding of AI, the findings related to awareness, usage, and evaluation of AI technologies raise significant concerns. Students' AI literacy levels are shaped by multiple factors, including limited access to technological devices, geographic disparities in resource availability, and insufficient opportunities for hands-on learning experiences. This underscores the urgent need for enhanced efforts to improve students' comprehension and skills concerning AI technologies, enabling them to compete effectively in an increasingly digitalized job market. The implications of these findings are substantial, particularly within the realms of education and technology development in Indonesia. Insufficient AI literacy may impede students' capacity to adapt to rapid technological advancements. Therefore, further research is warranted, including longitudinal studies to track the evolution of AI literacy over time and qualitative approaches to gain insights into students' experiences. Moreover, it is essential to develop educational programs prioritizing increasing awareness and utilization of AI technologies while investigating regional and gender-related factors that may influence AI literacy. Additionally, exploring the impact of student science contributions in social and natural sciences could provide a deeper understanding of how interdisciplinary approaches enhance AI literacy and its applications. Therefore, higher education institutions and academics should implement strategic measures to enhance students' AI literacy. A key strategy for higher education institutions is to evaluate and refine curricula to emphasize the enhancement of AI awareness and utilization, ensuring that students develop the necessary competencies to engage with AI technologies effectively. This entails conducting further research, including longitudinal studies to monitor the development of AI literacy over time and qualitative investigations to gain deeper insights into students' experiences. By implementing these measures, it is anticipated that students will be better equipped to confront the challenges of the digital age.

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